in the instruments of the Surface Stone Period it is nearly always the broad end that is sharpened, and this has often been effected by grinding or polishing the edges, while in the implements of the period we are now considering the edges are never ground. The name by which this period is generally known is the Palæolithic or Ancient Stone Period, though it is sometimes also termed the River-drift Period, as the implements belonging to it are usually found in river-drift. Of the other appliances in use among those who made the large palæolithic implements we can best judge by the remains which have been found beneath the floors of some of the caverns both of England and France, which, however, for the most part probably belong to a somewhat more recent date. In the days when those caverns were occupied as dwellings the reindeer still formed a principal article of food in the South of France. Those who hunted it were sufficiently good artists to carve figures of it in bone, or to engrave them on slabs of slate. Some representations of the elephant have also been found. They carved harpoons in reindeer horn, prepared skins with stone scrapers, and sewed them together by means of bone needles, probably using reindeer tendons as thread. The men, however, who were in this state of civilisation lived at a time when the valleys had been excavated to nearly their present depth, Yet even between them and the people of the Neolithic or Surface Stone Period there appears to be a great gulf—a chapter of unwritten history, which at present we have no means of reading.

Let us now return to the river-drift, and see what more it can teach us. I have told you how on the high ground where now is Southampton Common there are beds of gravel containing water-worn flint implements, and that these beds must in all probability have been deposited in the bottom of a river valley. Farther south we find gravels of a similar character, but at lower levels, forming cliffs of no great height along the sea-shore from Hambley to Alverstoke. These cliffs are now being eaten away by the action of the sea, and among the pebbles spread by the waves upon the shore numerous well-wrought implements have been found, while farther east, at Selsey, there are extensive drift-beds containing remains of the mammoth. Nor are traces of the river, which deposited these beds, wanting on the other side of Spithead, for in the shingle at Bembridge implements of the same kind have been discovered, and Mr. Codrington found a good specimen, some 80 feet above the present sea-level, in gravel on the Foreland at the east end of the Isle of Wight.

It will probably be some little strain upon your powers of imagination for you mentally to fill up the great channel of the sea which we know as Southampton Water, and which now forms the basis of the prosperity of this town, and to picture to yourselves a river flowing in the same direction, spreading out gravels along its changing course at a height considerably above the present sea-level, and yet having its shores frequented by that early race of men who fashioned the implements which we find in the gravels. But I shall have to make a still further demand upon your powers of belief.

I have already spoken to you about the drift-deposits along the valley of the Avon, but I must now take you a little farther west, and call your attention to discoveries which have been made at Bournemouth. There, as many of you no doubt remember, the cliffs are formed of beds of sand and clay belonging to a period a little older, geologically speaking, than the Bracklesham beds whch form the subsoil of Southampton. These cliffs are, however, capped with gravel; and in this, also, at a height of more than 120 feet above the sea-level, implements have been found. Farther east, near Boscombe, the height of the gravel is still about 120 feet; at Hengistbury Head it is 90 feet; and at Barton and Hordle, where numerous implements have been found, it is 60 or 70 feet. There can, indeed, be but little doubt that these gravels which now cap the cliffs must originally have been deposited in the bed of a river, and that that river flowed in an easterly direction. But how, it will be asked, can any river have possibly taken such a course? I will ask you, in return, Of what are the Needles at Alum Bay the relics? Are they not the shattered and sea worn remains of an extension of the great chalk ridge of High Down westward from Freshwater? Can you not imagine them still forming part of the down, with other Needles, which have now disappeared, towering still farther to the west? Can you not picture to yourselves the foreland of Ballard Down, on the Dorset coast, and its accompanying pinnacles standing out still farther to the east, and thus in your mind's eye gradually bridge over the gap of fifteen miles, which now exists between the chalk downs of Dorset and those of the Isle of Wight? There must almost of necessity have been a period when these two ranges of downs formed one continuous ridge, and when, in fact, the Isle of Wight was not separated from England by any arm of the sea. At that time the rivers which now discharge their waters at Poole, at Christchurch, at Lymington, and at Exbury, must all have been contributed to form a river the course of which must have been from west to east, in a direction nearly parallel to the chalk downs. Of the bed of this river we have traces in the gravels which now cap the cliffs of our southern coast. The history of the disappearance of this ancient river appears susceptible of being traced. We know not how far the land may have extended to the south of the chalk downs at the time when it first began to flow; but in the course of long ages the never-ceasing wear of the sea,slow but sure in its action, must have effected a breach through the line of chalk downs, and have then more rapidly cut away some of the softer beds to the north, so as to afford a new means of access by which the waters of the river would find a way to the sea. As time went on this breach would become wider and wider, until, as we see at present the whole of the southern slope of the old river valley disappeared for a distance of fifteen miles between Ballard Down and the Needles; while that part of the bed of the old river which still had land to the south was widened out until it became the Solent Sea and Spithead, which now separates the Isle of Wight from the mainland.

I might have given you evidence from which it has been concluded that, at the period when the river gravels containing flint implements were deposited, England was still united to the Continent, and the Straits of Dover did not exist. I might have pointed out the existence of similar implements discovered under nearly similar circumstances in remote quarters of the world. But time will not suffice, and you must be content with my attempt to read this chapter of local history. I must, however, warn you against supposing that, old as may be these relics they represent the first advent of man upon the earth. On the contrary, their similarity in so many regions points to some early home of the human family from which the makers of these flint tools in different countries originally migrated. Of this home, however, as yet no traces have been found. As to the number of years embraced in this chapter of the river-drift it is hard even to speculate. It can only be judged by the changes which have since taken place. We have seen how in the Roman times this part of Britain was, so far as the distribution of land and water is concerned, much the same as at present, and that there can have been but little difference in the days when bronze was in use for cutting-tools or in that lengenthened period when stone did duty for steel. But when we come to this earlier chapter in our history, all is changed. We find on the top of our hills and the capping of our cliffs gravels which must have been deposited at the bottom of rivers, but which testify to the existence of man at the time of their deposit. We find a total change in the animal world of the region; we find that deep valleys have been excavated and river-courses widened out into arms of the sea, and the whole shape and form of the country changed. No wonder if, with so wide a room for speculation, different observers adopt somewhat different readings of this chapter of unwritten history. I have given you my reading of it, in which I see the antiquity of man carried back so far into the dim past, that even Egyptian chronology, extending as it does over thousands of years, appears but to cover a small link in the long chain of human existence—a chain of which the first link has still to be discovered. If you on your part will attempt to check and verify my reading, and study attentively what is still going on under your eyes, it will bring home to you the mighty effects which may arise from the small but ever-active agents, rains and rivers, tide and time; and whether in the end you agree with my reading or not, you will find that you have added a new interest to your lives.

PROFESSOR HAECKEL ON DARWIN, GOETHE, AND LAMARCK[1]

WHEN five months ago the sad intelligence reached us by telegraph from England, that on April 19 Charles Darwin had concluded his life of rich activity, there thrilled with rare unanimity through the whole scientific world the feeling of an irreparable loss. Not only did the innumerable adherents and scholars of the great naturalist lament the decease of the head-master who had guided them, but even the most esteemed of his opponents had to confess that one of the most significant and influential spirits of the century had departed. This universal sentiment found its most eloquent expression in the fact that immediately after his death the English newspapers of all parties, and pre-eminently his conservative opponents, demanded that the burial-place of the deceased should be in the Valhalla of Great Britain, the national Temple of Fame, Westminster Abbey, and that there in point of fact he found his last resting-place by the side of the kindred-minded Newton.

---

[1] Lecture given at the Eisenach meeting of the German Naturalists and Physicians.

In no country of the world, however, England not excepted, has the reforming doctrine of Darwin met with so much living interest or evoked such a storm of writings, for and against, as in Germany. It is therefore only a debt of honour we pay, if at this year's assembly of German Naturalists and Physicians we gratefully call to remembrance the mighty genius who has departed, and bring home to our minds the loftiness of the theory of nature to which he has elevated us. And what place in the world could be more appropriate for rendering this service of thanks than Eisenach, with its Wartburg, this stronghold of free inquiry and free opinion! As in this sacred spot 360 years ago Martin Luther, by his reform of the Church in its head and members, introduced a new era in the history of civilisation, so in our days has Charles Darwin, by his reform of the doctrine of development, constrained the whole perception, thought, and volition of mankind into new and higher courses. It is true that personally, both in his character and influence, Darwin has more affinity to the meek and mild Melanchthon than to the powerful and inspired Luther. In the scope and importance, however, of their great work of reformation, the two cases were entirely parallel, and in both the success marks a new epoch in the development of the human mind.

Consider, first, the irrefragable fact of the unexampled success which Darwin's reform of science has achieved in the short space of twenty-three years! For never before since the beginning of human science has any new theory penetrated so deeply to the foundation of the whole domain of knowledge or so deeply affected the most cherished personal convictions of individual students; never before has a new theory called forth such vehement opposition and so completely overcome it in such short time. The depicture of the astounding revolution which Darwin has accomplished in the minds of men in their entire view of nature and conception of the world will form an interesting chapter in the future history of the doctrine of development.

In 1863, four years after the publication of Darwin's great work, opening up a new path for the human mind, when at the meeting of naturalists at Stettin, I for the first time openly drew attention to the work, the great majority were of opinion that "nature-philosophical fantasies" of this sort were no proper subject for earnest discussion. An esteemed zoologist pooh-poohed the whole theory as the "harmless dream of a man napping," while another compared it with table-turning and "Odic force." A celebrated botanist maintained that there was not one single fact to support this "untenable hypothesis," but that on the contrary it contradicted all experience, and a noted geologist believed that the passing vertigo would soon inevitably sink into dull sobriety. A well-known physiologist later on spoke of the whole history of filiation as a romance, and an anatomist prophesied that in a few years there would be no more talk of it. In thick-tomed works and in numberless treatises it was demonstrated that Darwin's theory was false from beginning to end, unproved by facts, delusive in its conclusions, ruinous in its consequences. Nay, no further back than five years ago, when in the meeting of Naturalists at Munich (1877) I expounded "the current doctrine of development in relation to the whole body of science," I encountered the most unqualified antagonism in one of our most celebrated naturalists, who even went the length of demanding the exclusion from education of Darwinism as an "unproved hypothesis." I was compelled in my paper on "Free Science and Free Teaching," to take the right of the latter emphatically under my protection.

And of all these damnatory judgments on the part of our numerous opponents, how much remains current at the present day? Nothing. The very number and bulk of their many-sided attacks have only redounded to the completion of our triumph. For the more the immovable citadel of the new theory of nature was attacked from all sides and assailed by weapons of the most varied kind, the more did its undaunted defenders feel called upon to fill up the gaps which here and there disclosed themselves in their inclosing wall of defence. Every charge on the part of the superannuated dogmas went to pieces against the iron panoply of the united experimental sciences. The gifted commander who had discovered the long-sought bond of union for the sciences, and had led the defence under the conception of oneness or monism, was able three years ago, on the celebration of his seventieth birthday, to look with entire satisfaction on the complete victory won by his troops, and with Goethe might say—

> "Es wird die Spur von meinen Erdentagen
> Nicht in Æonen untergehn"[1]

That such is really the case, and that in the evening of his life Darwin was enabled to rejoice in the complete triumph of his good cause is a fact indisputably testified by the present state of the natural sciences. We have only to cast a glance into the numerous periodicals and the most important works in those departments which are more immediately and more integrally affected by Darwin's teaching—zoology and botany, morphology and physiology, ontogeny and palæontology. In these subjects scarcely any work of superior merit now appears which is not penetrated by the idea of natural development. With vanishingly few and unimportant exceptions, almost all investigations start with the assumption of Darwin's fundamental conception, that the form-relationship between different species of animals and plants is rooted in their essential blood-relationship, and that the complicate relations of the organic world are to be explained by the two factors of common origin and gradual transformation.

Darwinism, too, in its more specific sense, the theory of selection, has maintained its ground in the face of all attacks; for this it is which first discovers to us the physiological causes through which the struggle for existence mechanically produces transformation. And if natural selection is by no means the only agent in transformation it at all events still remains its most important instrument. Darwin, by his discovery of it under the light of artificial selection, solved one of the greatest biological riddles. For the doctrine of "natural selection through the struggle for existence" is nothing less than the final solution of the great problem: "How can forms of organisms constituted for a particular purpose come into being without the aid of a cause acting with a particular purpose? How can an edifice replete with design build itself up without design and without architect?" A question which our greatest critical philosopher, Kant, a hundred years ago, declared to be insoluble.

But in no province of natural science do Darwin's grand achievements appear so conspicuous as the one in which our own investigations revolve, in the wide province of morphology, comparative anatomy, and the history of development. For in morphology, which was also Goethe's special favourite, *all* knowledge that is not merely superficial, depends directly on the recognition of the doctrine of filiation; and here it is, particularly, that by its help the most brilliant results have been attained in the shortest time. The genealogical trees of particular groups of forms, which at the beginning hardly dared venture into the light of day as new-fangled (*heuristische*) hypotheses, are now, in the case of many organic groups, completely established facts. To cite but a few examples, no competent zoologist any longer calls in question the descent of horses from tapir-like palæotheria, of ruminant animals from swine-like anoplotheria, of birds from lizard-like reptiles. Nor does any one any longer doubt that all higher air-breathing vertebrates have their origin in lower gill-breathing fishes. The most important and most disputed, however, of all hypotheses of descent, that, namely, which derives man from ape-like mammals, has of late years, in consequence of more matured knowledge, gained for itself such general recognition at the hands of competent experts, that the great majority of them now deem it just as well grounded as any of the foregoing phylogenetic hypotheses.

In the face of such encouraging unanimity we can afford quietly to ignore the opposition which is still raised here and there by some single opponents of transformation. There is one capital fact in our favour, the whole of the younger generation is working in Darwin's spirit, and far beyond the limits of professional circles his doctrine is operating as a ferment, stimulating to nearer solution the greatest problems of human knowledge.

Celebrating here to-day the complete victory of Darwin's doctrine of development, as we are, accordingly, entitled to do, it is also implied that the end has come to the dreary period of violent literary warfare; and we may give all the more emphatic expression to our jubilant feeling of triumph in this respect, that we have ourselves been largely involved in those hard battles. Seeing, however, that according to Heraclites, struggle is the father of all things, it was not possible that the struggle for existence should spare the theory which itself laid down this principle and raised it to be the most valuable instrument in its store-house of arguments. With all the greater welcome we now greet the new period of peace following on that victory, and of quiet progress in which we look forward to the fairest fruits in the new courses of inquiry. It well becomes the Association of German Naturalists and Physicians who have repeatedly been witnesses of the loud tumult of those battles, now when they are happily concluded, to sanction the treaty of peace, and to solemnly recognise the doctrine of development as the sure foundation-stone of scientific inquiry.

---

[1] The influence of my earthly days
Will last through eons.

If we now look for the causes of the extraordinary effect produced in such a short time by the Darwinian doctrines, in the teeth of the most violent opposition, we will find them by no means exclusively in the convincing force of their inherent truth, but also in the peculiarly favourable outward circumstances in which they entered the scientific world. Not the least of these favourable conditions lies in the rare characteristic qualities of the man on whom devolved the solution of such a gigantic task. Charles Darwin united in himself a wealth of diverse intellectual gifts which generally are to be found only apart. His fund of knowledge and his acumen as a naturalist were just as great as his far-sightedness and comprehensiveness as philosopher. To what degree he harmoniously combined these two sides of intellectual activity, often in conflict with each other, may be inferred from the fact that many short-sighted experimentalists see in him only the conscientious observer and ingenious experimentalist, regretting that his theory should be but speculative aberration; while on the other hand many high aspiring thinkers look down with great depreciation on his experimental achievements, but admire the acuteness of his judgment and the lucidity of his logical train of thought. In this respect he reminds us of our two greatest German naturalists, Johannes Müller and Carl Ernst Baer. If the latter in his title-page described his classical "History of the Development of Animals" as "Observation and Reflection," Darwin might say the same of all his works. With these rare powers of observation and judgment were associated other noble qualities of character greatly enhancing their value and profit; indefatigable perseverance in the pursuit of his aims, scrupulous conscientiousness in grouping the assured results, purest aspiration after natural truth, and open simplicity in communicating his conclusions. No less praiseworthy was the extraordinary modesty with which he set forth his views, and the mild meekness with which, while answering all the sharp objections of his opponents, so far as they were to the purpose, he simply ignored personal aspersions.

Truly admirable is the patience and forethought with which Darwin took in hand and carried out the weightiest task of his life—the explanation of the origin of animal and vegetable species through natural selection. The first basis to this work was laid in his twenty-third year, when in 1832, in South America, he drew up geographical and palæontological observations on the animal species of this continent. The rich observations he accumulated in that voyage round the world, a voyage lasting five years, and of such consequence to him, did not, however, come to their full utilisation till long afterwards. The injury to his health wrought by the severe hardships to which that voyage subjected him forced him to withdraw completely from the restless turmoil of London, and to reduce his circle of personal friends to the narrowest compass. In 1842, in the thirty-third year of his age, he betook himself to his quiet, idyllic country seat of Down, lying gracefully between the green meadows and the wooded hills of the sweet county of Kent.

In the harmonious solitude of this verdant seat of the Muses Darwin lived full forty years, devoting himself singly and exclusively to the continuous study of nature and to the solution of the great problem she had revealed to him. Practising, himself, for many years the active work of gardener and cattle-rearer, he could see under his own eyes the transformation of the corporeal forms of plants and animals. Examining into the physiological causes of these transformations, the laws, namely, of Inheritance and Adaptation, he clearly perceived that in the domain of uncultivated as well as of cultivated nature the same mechanical laws condition change of species. He became convinced that artificial and natural rearing rested essentially on the same processes of selection. What in the one case is produced in a short time by the purposively active will of man for his own advantage is in the other produced in a much longer time by the purposelessly active "Struggle for Existence" to the advantage of the transformed organisms.

But although Darwin had early conceived this fundamental thought of his "Theory of Selection," and throughout many years had collected the richest material of observations in its evidence, he could not for a long time resolve on the publication of his theory. It would ever appear to him too full of gaps, the mass of facts required for its support too defective, the chain of inferences too incomplete. He was ever wanting to accumulate fresh evidence, to bring ever more light from all sides on the questions in hand, and as far as possible to anticipate and refute objections to his conclusions. Perhaps in the end he would never have come to communicate the treasures of his knowledge to the world, had it not been for an outward impulse which constrained him to this step. At length then, in 1859, after the author had completed his fiftieth year, appeared his era-inaugurating chief work on the "Origin of Species," a work to which all the rest of his writings are but deductions and commentaries. This event happened just a full century after Caspar Friedrich Wolff in Germany had discovered the true development of the animal germ, and just half a century after Lamarck in France had prophetically propounded the principles established by Darwin.

The extraordinary modesty and unassumingness which Darwin showed to such a degree on the subject of the publication of the most important of his writings, displayed itself also on all hands in his extensive correspondence, and not less in his personal intercourse. Every one who had the happiness of making his personal acquaintance could not part from him without a feeling of the sincerest reverence and highest appreciation. Were it here allowed me to intercalate a few words on my personal meeting with Darwin, I would give expression especially to the high admiration of Darwin as an ideal man with which my three visits to him in Down inspired me. The first time was in October 1866, on the occasion of a voyage I was undertaking to the Canary Islands. I had just completed the "General Morphology," a work in which I had ventured on the experiment of mechanically establishing the science of organic forms on the basis of the theory of filiation as reformed by Darwin. By means of the proof-sheets I had sent him, Darwin was acquainted with my essay, and took all the more interest in it because these morphologic investigations lay rather remote from his own studies, which were principally experimental. It was, therefore, with the greatest pleasure that I responded to an invitation to come to Down, which he had sent me during my short stay in London.

In Darwin's own carriage, which he had thoughtfully sent for my convenience to the railway station, I drove one sunny morning in October through the graceful hilly landscape of Kent, that, with the chequered foliage of its woods, with its stretches of purple heath, yellow broom and evergreen oaks, was arrayed in the fairest autumnal dress. As the carriage drew up in front of Darwin's pleasant country-house clad in a vesture of ivy, and embowered in elms, there stepped out to meet me from the shady porch overgrown with creeping plants, the great naturalist himself, a tall and venerable figure with the broad shoulders of an atlas supporting a world of thoughts, his Jupiter-like forehead highly and broadly arched, as in the case of Goethe, and deeply furrowed by the plough of mental labour; his kindly mild eyes looking forth under the shadow of prominent brows; his amiable mouth surrounded by a copious silver-white beard. The cordial prepossessing expression of the whole face, the gentle, mild voice, the slow, deliberate utterance, the natural and *naïve* train of ideas which marked his conversation, captivated my whole heart in the first hour of our meeting, just as his great work had formerly, on my first reading it, taken my whole understanding by storm. I fancied a lofty world-sage out of Hellenic antiquity—a Socrates or Aristotle—stood alive before me.

Our conversation, of course, turned principally on the subject which lay nearest the hearts of us both—on the progress and prospects of the history of development. Those prospects at that time—sixteen years ago—were bad enough, for the highest authorities had for the most part set themselves against the new doctrines. With touching modesty Darwin said that his whole work was but a weak attempt to explain in a natural way the origin of animal and vegetable species, and that he should not live to see any noteworthy success following the experiment, the mountain of opposing prejudice being so high. He thought I had greatly over-estimated his small merit, and that the high praise I had bestowed on it in my "General Morphology" was far too exaggerated. We next came to speak of the numerous and violent attacks on his work, which were then in the ascendant. In the case of many of those pitiful botches, one was in fact quite at a loss whether more to lament the want of understanding and judgment they showed or to give the greater vent to the indignation one could not but feel at the arrogance and presumption of those miserable scriblers who pooh-poohed Darwin's ideas and bespattered his character. I had then, as on later occasions, repeatedly, expressed my just scorn of the contemptible clan. Darwin smiled at this, and endeavoured to calm me with the words, "My dear young friend, believe me, one must have compassion and forbearance with such poor creatures; the stream of truth they can only hold back for a passing instant, but never permanently stem."

In my later visits to Down in 1876 and 1879 I had the pleasure of being able to relate to Darwin the mighty progress which in the past intervals his doctrines had made in Germany. Their decisive outburst happened more rapidly and more completely here with us than in England, for the reason chiefly that the power of social and religious prejudice is not nearly so strong here as among our cousins across the Channel, who are better placed than ourselves. Darwin was perfectly well aware of all this; though his knowledge of our language and literature was defective, as he often complained, yet he had the highest appreciation of our intellectual treasures.

Darwin having in his great work of 1859, planting the basis of his doctrine, said nothing regarding its anthropological consequences, and having with wise reserve maintained silence on this subject down to the year 1871, it was for me of the highest interest, even as early as my first visit to him in 1866, to converse with him at large on that topic. As was to be expected, the great thinker felt not the slightest misgiving in recognising the necessary extension to man of the application of his doctrine of filiation. I had, therefore, the highest satisfaction in being able to set forth to him the first genealogical tables which I had then designed, and in all essential points to receive his approval. Though the special study of comparative anatomy and ontogeny, on which I based my phylogenetic plans, lay out of Darwin's province, he yet completely perceived their importance. In his celebrated work, in two volumes, on the "Descent of Man and Selection in relation to Sex" (1871), he has, therefore, declared himself to be in all principal points in harmony with me, and has expressly emphasised the importance in relation to the history of filiation of the numerous animal hereditary relics we possess in our human vertebrate organism.

If now we survey the huge mass of facts which in this and other works Darwin has gathered together with just as much forethought as boldness to serve as a support for his ideas—if we regard the innumerable observations and experiments he has himself instituted to establish their accuracy, we cannot but wonder at the strength of the giant-mind which has amassed such an abundance of knowledge and power, of experimental knowledge and philosophical science in the narrow compass of a single human life. Involuntarily we exclaim what a rare constellation of happy circumstances there must have been to render possible such extraordinary performance conjoined with commensurate success.

We must then, undoubtedly, admit that in the case of Darwin, merit and fortune went hand in hand, and that rare favour on the part of fate made it possible for him to execute completely his great life-task. Free from all the cares and worries of a week day existence, enjoying in security a comfortable home and a happy family life, undisturbed by professional business and official duties, he was able to devote himself throughout half a century exclusively to his favourite studies. While the solitude of his tranquil country-seat saved him from the turbulent traffic in knowledge which in large cities consumes the best powers of a man, it also supplied him with those conditions which were most favourable to the composure and harmony of his rich world of thoughts. In our opinion nothing is more prejudicial to scientific work of a deep and earnest character than the pedantic wrangling of our great universities and the partisanship of scientific colleges. From this as from all posts of honour and other such disturbing influences of the outside world Darwin his whole life long kept himself remote, and he acted wisely in so doing!

While, therefore, the great naturalist owed his unexampled success in the first place to himself and his noble endowments, some share in the credit must also be allowed to the favourable scientific situation of the time, which was furthersome in a high degree. Ever since the failure of the older nature-philosophy in the beginning of our century, since Goethe and Kant in Germany, Lamarck and Geoffroy in France, failed in their attempts to direct the minds of men to the natural development of the organic world, a strictly experimental method became the universal practice in the domain of biology. The task thus set before scientific labourers was that of the most exact investigation into all the particular forms and phenomena of animal and vegetable life; the monistic explanation of the whole, and, in particular, the solution of the problem of creation being abandoned. The foundation of embryonic history by Baer, of comparative anatomy and palæontology by Cuvier, the reform of physiology by Johannes Müller, the propounding of the theory of cells and of the doctrine of tissues by Schleiden and Schwann had opened up new and grand provinces to natural experiment, whence was drawn by numerous labourers inquisitive for knowledge an astounding abundance of facts. In the short space of half a century there arose quite a series of new sciences.

The more, however, that from year to year the number of new discoveries accumulated, the higher that the flood of literature swelled, the more confused became the chaos of the general theory of nature, and the greater was the necessity felt by thoughtful inquirers for an elevation above the stifling mass of detached observations to universal monistic points of view and to the knowledge of real causes. This requirement was now most happily met by the new doctrine of development. It is true that, as early as 1809, in the year of Darwin's birth, Lamarck had clearly demonstrated that the similarity of organic forms was to be explained by their common derivation and their diversity by their adaptation to the conditions of existence. He had, however, failed to attain a knowledge of the active causes which Darwin fifty years later disclosed in his theory of selection.

It is therefore in complete contradiction with the historical facts and a proof of utter ignorance of the history of biology, when even at the present day a few individual opponents of Darwinism declare the theory to be a vague hypothesis, in support of which evidence has yet to be adduced. In reality the very opposite is the case. The actual evidence for the common descent of the manifold forms of life had already long been adduced before it was formulated by Darwin into a clear scientific theory. Numerous physiological experiments even had long before been carried out in support of it. For the total results of our horticulture and animal rearing—and the mass of new forms of life which civilised man has artificially produced to his own profit and advantage are just so many experimental proofs of the theory of selection. And as concerns the "struggle for existence," the essential element in Darwinism, no particular arguments, in truth, are needed; for the whole history of mankind is nothing else!

Our whole science of living nature, which in one word we designate Biology, was, accordingly, perfectly prepared for the reception of the fertilising ideas of Darwin, and hence in large measure we explain their extraordinary success, in contrast with the pre-maturity and inefficacy of the similar theories of his predecessors. The high merits of these predecessors Darwin with his noble sense of justice has on all occasions recognised. It is, therefore, far from the spirit of the great master when in our day some over-zealous disciples of his (particularly in England) are intent on celebrating him as the sole founder of the new doctrine of development, as though it had all at once sprung ready-made from the head of the thinker, like Minerva armed from the forehead of Jupiter. On the contrary, we believe that we are acting perfectly in the spirit of our deceased master and friend if we here call to honourable remembrance his great predecessors. The splendour of his name can only be enhanced by showing that in the most important principles of his theory of nature he was in unison with a select number of the greatest minds the history of human civilisation can boast of.

We have to go back no less than twenty-five centuries, into the grey fore-time of classic antiquity, to come upon the first germs of a philosophy of nature, pursuing Darwin's goal with distinct consciousness; the demonstration, namely, of natural causes for the phenomena of nature, and thereby the eviction of faith in supernatural causality, of faith in miracles. The founders of the Greek philosophy of nature in the seventh and sixth century before Christ were the first who laid down this true foundation-stone of knowledge, and endeavoured to discover a natural common original basis of all things. This conscious aspiration after absolute causality, after the unifying knowledge of a common cosmic cause, appears all the more admirable that proper experimental investigation of nature was at that time quite out of the question.

Perhaps the most important among these Ionian natural philosophers was Anaximander. He assumes that out of infinity of matter through eternal revolution numerous world-bodies came into being as condensations of the air, and that the earth, too, as one of these world-bodies, issued out of a state originally fluid and afterwards aëriform. He consequently anticipated the fundamental conception, valid at this day, of the natural development of the world, which 2400 years subsequently, in 1755, our greatest German philosopher, Immanuel Kant, in his "Universal History of Nature and Theory of the Heavens," universally established. As here in the cosmological kingdom, Anaximander appears as forerunner of Kant and Laplace, so also at the same time in the biological kingdom he prophetically prefigures Lamarck and Darwin. For according to him the earliest living creatures on this globe originated in water through the operation of the sun. From these creatures, later on, were developed the land-inhabiting plants and animals which left the water and adapted themselves to life on dry land. Man, likewise, has gradually worked himself up from animal organisms, and, in reality, from fish-like aquatic animals.

If here to our surprise we find clearly enunciated some of the most important fundamental conceptions of our current theory of development, we recognise it still more distinctly in its integrity one hundred years later in Heraclites of Ephesus. He it was who first propounded the principle that a great uninterrupted process of development prevades the whole universal world, that all forms are involved in an everlasting current, and that struggle is "the father of all things." Seeing that nowhere in the world exists absolute rest, and that all standing—still is but apparent, we are compelled everywhere to assume a perpetual change of matter, a constant variation of form. That is only possible, however, through the fact that one form thrusts out the other, and that the new violently usurps the place of the old; or, in other words, through the universal "struggle for existence."

This principle of nature set forth by Heraclites that everlasting movement or the struggle among all things is the fundamental agent of the world received a much deeper interpretation a little later in Empedocles of Agrigent in Sicily. He, too, assumes an uninterrupted change of phenomena, but finds the universal fundamental cause of the everlasting universal struggle in the two counteracting principles of hate and love, or, as our modern physics expresses it, of the attraction and repulsion of parts. As the mixture of bodies is effected by love so is their separation by hate. If in the present day we regard the attraction and repulsion of atoms as the ultimate ground of all phenomena we find, then, this fundamental proposition of our modern doctrine of atoms already anticipated in Empedocles. It is however still more remarkable that Empedocles makes the purposive forms of organisms come into existence through the accidental conjunction of counteracting forces. Out of this great struggle the living forms now existing have issued victoriously because they were best prepared for the battle, and therefore most capable of life. Here we have not only the fundamental conception of Darwin's theory of selection forestalled, but also the solution of the great riddle indicated, "How can organic forms constituted for a particular purpose come into existence in a purely mechanical way without the co-operation of a final cause acting with a particular purpose?"—the same riddle the solution of which we account to be Darwin's highest philosophical merit.

Among all the great philosophers of classical antiquity, the three we have already named, Anaximander, Heraclites, and Empedocles, are undoubtedly those who have most clearly enunciated the most important elements of the monistic theory of nature now prevalent. But besides these we find other contemporaries of theirs who held similar conceptions of development, such as Thales, Anaximenes, Democritus, Aristotle, Lucretius, &c. Yet were these various attempts at a genetic theory of nature soon thrust into the background by an opposing scheme of the world, that, namely, of the "Philosophy of Ideas," which was propounded by the sophists, and had its centre in Plato.

If these fresh-minded experimentalists of Ionian philosophy sought to explain the totality of the world by natural causes through mechanical processes, the Platonic school set up, in opposition to this view, supernatural causes, in the form of teleological ideas. There thus arose a mode of thought and inquiry which, withdrawing the mind from the objective knowledge of nature, placed the subjective being of man in the forefront of our contemplations, a mode which throughout a space of more than 2000 years exercised its baleful influence in ever increasing measure. In complete contradistinction to the "Unity of Nature," everywhere demonstrated by the causality of her phenomena, there developed mightily the dualism invented by Plato, a harsh antithesis between God and world, between idea and matter, between force and stuff, between soul and body. The numerous forms of organic nature which we distinguish as animal and vegetable species no longer appear as different stages in the development of common original forms, but as embodiments of so many innate, eternal and unchangeable "ideas," as "constant species"—or, as Agassiz, Darwin's greatest opponent, expressed it, "embodied creative thoughts of God."

This Platonism found its strongest support in the dogmas of Christianity which preaching retirement from nature came into friendly agreement with the "philosophy of ideas." The accelerating decline, again of the sciences which followed the tragic destruction of noble Hellenism operated in favour of both Platonism and Christianity. Throughout the whole long spiritual night of the Christian Middle ages there was no inward impulse to a monistic theory of nature on the ground of experimental investigation. In truth, however, there were not wanting attempts in this direction on the ground of pure speculation. In particular, the Pantheistic systems of Giordano Bruno and of Benedict Spinoza in the sixteenth and seventeenth centuries are admirable essays towards a monistic and natural comprehension of nature. These Pantheistic cosmologies, however, which in all material things assume an impelling world-soul in inseparable unity, were yet especially directed on the province of ethics or practical philosophy, and lacked, alas too desperately, all experimental foundation through immediate observation of nature—for in truth there was then no such thing. The whole sense and tendency of most thinkers of that time were turned away from Nature and bent exclusively on man, who was considered to hold a position beyond and above Nature. Even those monistic systems, therefore, of Bruno and Spinoza had no power to establish themselves in the face of the all-mighty dualism which, through Platonism and Christianity, attained to universal supremacy.

Not till a long period afterwards, not till the middle of the last century, did the natural reaction against that dualistic scheme of the world finally assert itself. Then at length did man begin to turn to the true source of all knowledge, to nature herself. Especially in regard to the knowledge of animate bodies in nature, knowledge which had hitherto for two thousand years been drawn almost exclusively from the well of Aristotle, a new era of independent observation sprang up. The outward form and inward structure of plants and animals, their vital phenomena, and their development were now for the first time the subject of zealous and extensive investigation on the part of numerous naturalists. The plenitude of interesting facts which this source of natural revelation supplied could not, however, but again excite inquiry after the efficient causes, and soon the idea of natural development as an answer to the question forced its way out again.

The so-called school of the "older philosophy of nature," towards the end of the last and the beginning of the present century, first appears, simultaneously in Germany and France, as the new banner-bearer of this idea. But independently of this school, we see a number of the greatest thinkers and poets of our classical literary period moved by the same idea, above all Goethe, Lessing, Herder, Kant; later, Schelling, Oken, and Treviranus. In France, again, we notice Lamarck, Geoffroy St. Hilaire, and Blainville; in England Erasmus Darwin, the grandfather of our reformer who, in accordance with the laws of latent heredity, transmitted a whole series of characteristic intellectual qualities to his grandson. Time does not allow us to-day to follow with a view towards comparison of the different expressions of the conception of development in these eminent thinkers, and, besides, much in this respect is already universally known. We will on this occasion confine our attention to two of the most eminent minds, to Goethe and Lamarck—as in our opinion, of all Darwin's predecessors, they are the most important.

The significance of Goethe as naturalist has in our time been so often and so searchingly treated by several of our most esteemed biologists, that we may assume the most of it also to be common property. We will therefore on this occasion expound only that point which for us to-day is of quite peculiar interest, and has at the same time been very variously conceived, the question, namely, how far the general theory of nature held by our greatest poet agrees with Darwin's. In 1866 in my "General Morphology" I placed Goethe and Lamarck side by side with Darwin as the most important of the founders of the theory of filiation, and in the way of evidence had compiled from their writings a great number of specially remarkable passages. Their number has lately been increased by others. In the case, however, of a universal genius like Goethe, the question depends far less on the number and form of particular passages in which he communicates his view of the "formation and transformation of organic natures" as on the whole spirit of his grand and thoroughly monistic theory of nature, and on this subject those who have a general knowledge and comprehension of Goethe cannot now entertain any doubt. In that valuable legacy entitled "God and the World" he has left us in superabundance a collection of confessions as perfectly beautiful in their form as they are significant in their substance.

The preface to these confessions, the Proem, at once expresses the fundamental monistic thought of Goethe's general view of nature, the inseparable unity of Nature and God, in a manner which leaves us in no doubt:—

"Was wär' ein Gott, der nur von aussen stiesse,
Im Kreis das All am Finger laufen liesse!
Ihm ziemt's, die Welt im Innern zu bewegen,
Natur in Sich, Sich in Natur zu hegen,
So dass was in Ihm lebt und webt und ist,
Nie Seine Kraft, nie Seinen Geist vermisst!"[1]

Consider, in addition, the following wonderful poems: "The World-Soul," "One and All," "Legacy," "Parabase," "Epirrhema," &c.; consider, moreover, his pronounced confession to Spinoza's doctrine, and we cannot really find any essential divergence from our current monistic comprehension of the world as newly established by Darwin. And what a high value Goethe himself attaches to it is seen in his question:—

"Was kann der Mensch in Leben mehr gewinnen
Als dass sich Gott-Natur ihm offenbare,
Wie sie das Feste lässt zu Geist verrinnen,
Wie sie das Geisterzeugte fest bewahre?"[2]

That, accordingly, our great Prince of Poets considered the world only as a monistic process of development in the sense of the Hellenic philosophy of nature, is further demonstrated, among other passages, by the dialogue between Thales and Anaxagoras in the Classical Walpurgis-Night. We would also point out the emphasis with which in geology he held fast to the theory of a gradual and uninterrupted development of our planet and its mountains. From the very beginning he was the most decided opponent of the fallacy of repeated violent revolutions in our globe, a fallacy which developed itself in the beginning of our century, and through Cuvier, in particular, came to be generally accepted. "The violence and leaps in this doctrine," he said, "I cannot away with, for they are not in accordance with nature. Be the matter as it will, it must stand written, that I curse this confounded hurly-burly apparatus of the new creation of the world. And, assuredly, a talented young man will yet arise with the courage to oppose this universal craze!" Only a few years passed till this expectation was fulfilled. For in 1830 appeared Darwin's like-minded countryman, the great geologist, Charles Lyell, and delivered his continuity-theory, the doctrine which is now universally received, of the gradual and uninterrupted development of the earth from natural causes, a mechanical geological theory which, perfectly in Goethe's sense, excluded all violent revolutions of the earth from supernatural causes.

If here in the province of geology Goethe shows himself as a most decided adherent to a monistic theory of development, we find him much more so in the province of biology. For the knowledge of the living substance, this "precious, glorious thing" was truly his peculiar pet-study. Here, especially in Morphology, his "Doctrine of Forms," he has cast glances into the inner origin and birth of organic forms, glances deep and clear such as were possible only to a genius who was simultaneously thinker and artist, naturalist and philosopher.

Among the many interesting contributions Goethe has made to morphology, the most valuable and most elaborate is the "Metamorphosis of Plants," which appeared in 1790. In this mature product of his botanical studies, which lasted throughout many years, and which most seriously engaged him during his travels in Italy, he deduces, as is well known, the whole endless wealth of forms in the vegetable world from one single protoplant, and makes all its different organs come into being through manifold transformation and process of development on the part of one single fundamental organ, the leaf. With this work occurred, in point of fact, the first attempt to refer the endless multiplicity of individual vegetable forms to one common original type.

"Alle Gestalten sind ähnlich, doch keine gleichet der andern;
Und so deutet das Chor auf ein geheimes Gesetz.[1]

This "secret law," this "sacred riddle," is the common descent of all plants from that protoplant, conjoined with the fact that the special differences are effected by the different circumstances and conditions of their existence.

As in the "Metamorphosis of Plants," so also in the "Metamorphosis of Animals," Goethe seeks, likewise, after the common prototype out of which all the allied forms have been produced through diverging development.

"Alle Glieder bilden sich aus nach ew'gen Gesetzen,
Und die seltenste Form bewahrt im Geheimen das Urbild.
Also bestimmt die Gestalt die Lebensweise des Thieres,
Und die Weise zu leben, sie wirkt auf alle Gestalten
Mächtig zurück. So zeiget sich fest die geordnete Bildung
Welche zum Wechsel sich neigt durch äusserlich wirkende Wesen."[2]

As is clearly seen in numerous other passages of his morphological studies on "Formation and Transformation of Organic Natures," that "primal form" or "type" was the inward original community which lies at the basis of all organic forms and the original formation-tendency which is transmitted by inheritance. On the other hand, the "unrestrainable progressive transformation which arises from the necessary conditions and relations of the external world," is nothing else than *Adaptation* to outward conditions of existence. This latter is the centrifugal formative-energy of "Metamorphosis"; the former, again, is the centripetal formative-energy of "Specification." The clear knowledge of these two formative-energies, counteracting and balancing each other, was so highly prized by the poet that he enthusiastically extols it as the "highest thought to which creative nature soared."

The province in animal morphology to which Goethe applied himself with peculiar predilection was comparative osteology, the skeleton-theory of vertebrates. The reason for this is to be found in the fact that nowhere perhaps to such a degree as here does the operation of that highest nature-conception of manifold development out of one single typical fundamental form meet us with such all convincing force. Down to the present day, consequently, the comparative skeleton-doctrine has remained the special favourite of morphologists. While in this province Goethe demonstrated the unity of the vertebral formation in the different divisions of vertebrates, and while in his celebrated skull-theory he further showed that the skull was composed of a series of transformed vertebræ, he arrived in 1796 at the following remarkable utterance: "So much then have we attained as to be able to assert without any misgiving that all the more perfect organic natures—under which we imply fishes, amphibious animals, birds and *mammals with man at their head*—have all been formed after one original image, which in its highly persistent parts only deviates more or less here and there, and yet daily by propagation transforms and perfects itself."

Some of our opponents have raised the objection that these and similar passages of Goethe are no "scientific truths," but only poetical or rhetorical flourishes and images; the type he meant was only an "ideal pro-type," no real genealogical form. It appears to us that this objection betrays little understanding of the greatest German genius. He who is acquainted with Goethe's thoroughly objective mode of thought, who appreciates his thoroughly living and realistic view of nature, will, with us, entertain no doubt that under that "type" was intended a perfectly real descent of kindred organisms from a common genealogical form. That the great understander of man did not thereby exclude man from the development series of the other vertebrates is indicated with special clearness in his comparison of the human skull with that of lower mammals. He here expressly points out several places in the human skull as remains of the animal skull "which are found in stronger proportions in such a low organisation, but have not quite disappeared in man, in spite of his elevation."

---

[1] What kind of God were He who impelled things only from outside, and let the universe twirl round His finger! It seems proper to Him to move the world inwardly, to cherish nature in Himself, Himself in Nature, so that whatever lives and works and exists in Him never misses His power nor His spirit!

[2] What greater gain in life can man achieve than the revelation of God-Nature to him, the evolution of spirit from substance and the substantiation of spirit?

[1] All forms are similar, yet no one exactly the same as the other; and so the chorus points to a secret law.

[2] All members work themselves up according to everlasting laws, and the rarest form preserves in secret the primitive type. The form, therefore, determines the animal's mode of life, while, reciprocally, the mode of life reacts powerfully on all form. Thus the regulated structure firmly maintains to itself whilst yielding to change through the action of outward substances.

No less does his celebrated discovery of the intra-maxillary bone testify to the same conviction. Man, like the other mammals, having cutting teeth must also, Goethe concluded, possess the intra-maxillary bone which showed itself in the other mammals; and in point of fact after the most careful anatomical investigations he established his point, although it had been disputed by the highest anatomical authorities.

Highly remarkable, moreover, in this respect is the agreement Goethe expresses with the kindred view of Kant in his "Critique of the Faculty of Judgment," a work the "great main thoughts of which were entirely analogous with his own work, action, and thought hitherto." The great Königsberg philosopher had enunciated the descent of all organic beings from a common original mother (from man down to polyp) as a hypothesis which "alone was in harmony with the principle of the *Mechanism of Nature, without which a Science of Nature was altogether impossible*." This theory of descent, however, he had at the same time called "a daring adventure of reason." In reference to this passage Goethe remarks: "Had I first unconsciously and in obedience to inward impulse restlessly pressed forward in the direction of that Original Form, that Type—had I even succeeded in building up a scheme conformable with Nature; now at length could nothing hinder me from *boldly maintaining* the *Adventure of Reason*, as the sire of Königsberg calls it."

Finally, nothing can more strongly show the extraordinary interest with which Goethe followed this transformation-theory, down to the end of his life, than the well-known attention he gave to the dispute between Geoffroy St. Hilaire and Cuvier. "This event is for me of altogether incredible importance," exclaims the grey-headed old man of eighty-one years, with youthful fire, "and I have a right to jubilate over the universal victory, at last witnessed, of a cause *to which I have devoted my whole life*, and which, too, is mine in a quite especial manner." The vivid representations of this most significant dispute, completed by Goethe in March, 1832, just a few days before his death, is the last literary legacy the greatest poet and thinker of the German nation has left behind him; and to this great intellectual contention also his last word applies, "more light."

It is deeply to be regretted that the "Philosophie Zoologique," by Lamarck, a work of the highest moment which appeared in 1809, was wholly unknown to Goethe. For just in the development theory of this work, which is quite differently arranged and strictly systematically composed, he would have found much that was wanting to himself, much that would have yielded him the most complete supplement for his own incomplete studies. In reference as much to the monistic and complete elaboration of the development theory as to the many-sided experimental establishment of it on fact, the great work of Jean Lamarck is much more important than the similar essays of all his contemporaries, more particularly of the like-named work of Geoffroy St. Hilaire. When one considers with what extraordinary interest Goethe took up the latter work, it may be concluded that he would have given a much warmer reception still to the rich-thoughted work of Lamarck.

We cannot but regard it as a truly tragic fact, that the "Philosophie Zoologique" by Lamarck, one of the greatest productions of the great literary period in the beginning of our century, met, from its outset, with but extremely little attention, and in the course of a few years was utterly forgotten. Not till Darwin fifty years later on breathed new life into the Transformation theory therein established, was the buried treasure again brought into the light of day, and we cannot now but describe it as the completest representation of the theory of development prior to the time of Darwin. Nay, it seems to us the necessary atonement of a great historical injustice, if again to day (as was done sixteen years ago in the "General Morphology"), we place the great Frenchman side by side with the greater Briton and the greatest German. Each of the three great middle—European nations of culture has in the course of a century presented mankind with an intellectual giant of the first rank, who grasped in its entire significance the fundamental conception of the monistic development of the world from natural causes.

It would carry us much too far were we here to attempt setting forth an abstract of Lamarck's work and comparing it with Darwin's. It will suffice to cite some of the weightiest fundamental conceptions which characterise his theory of nature, and indicate how far he was in advance of his time. For many decades the great French biologist had occupied himself very searchingly with systematic botany and zoology. Testimony of this we have in his two celebrated and much used special works, the "Flore française," and the "Histoire naturelle des animaux sans vertèbres." While he was engaged in substantially classifying and describing not merely the forms already in existence, but also their extinct ancestors which he incorporated into his system, there was disclosed to him the inner morphologic connection between the former and the latter, and from this disclosure he inferred their common descent. All animal and vegetable forms which we distinguish as species, possess, accordingly, but a relative temporary persistence, and the varieties are the beginnings of species. The form-group of the species is, therefore, just as artificial a product of our analytic understanding as is the genus, the order, the class, and every other category of the system. The change in the conditions of life, on one hand, the employment or non-employment of the organs, on the other, exercise a constantly transforming influence on the organisms; they effect by means of adaptation a gradual transformation of forms, the fundamental lineaments of which are through inheritance transmitted from generation to generation. The whole system of animals and plants is in reality, therefore, their genealogical tree, and portrays to us the relations of their blood-kindredship. The course of development of life on our globe was, accordingly, continuous and uninterrupted, just as was the course of development of the earth itself.

While Lamarck thus clearly enunciates all the essential fundamental conceptions of our current doctrine of filiation, and by the depth of his morphological knowledge excites our admiration, the clear advanced outlooks he takes in his conceptions of physiology are no less surprising. While in his time the fallacy of a supernatural vital force was yet universally prevalent, Lamarck rejected that idea, and maintained that life was only a very complicated physical phenomenon. For all vital phenomena are based on mechanical processes which are themselves conditioned by the constitution of organic matter. The phenomena of soul-life (*Seelenlebens*) are also, in this respect, not different from other vital phenomena. For the ideas and activities of the understanding are based on motional processes in the central nerve-system; the will in truth is never free, and reason is only a higher degree of development and combination of the elements.

In these and other propositions Lamarck raises himself far above the general theory of nature held by most of his contemporaries, and sketches a programme of future biology which only in our days has come to be carried out. In view of the great clearness and consistency of his system it is only a matter of course that he should assign to man his natural place at the head of the vertebrates, and explain the causes of his transformation out of ape-like mammals. With equal acumen, however, he handles one of the darkest and most difficult questions of the whole theory of development, the question regarding the origin of the first living beings on our globe. For the answering of this question he assumes that the common earliest genealogical forms of all organisms were absolutely simple beings, and that they came into existence immediately out of inorganic matter in water by *Spontaneous generation*, through the combined effect of different physical causes. Such simplest organisms, however, were at that time not yet at all discovered; not till half a century afterwards were they actually come upon in the Monera.

Lamarck reached the great age of eighty-five years; consequently he lived two years longer than Goethe, and twelve years longer than Darwin. But while the two latter enjoyed the happiness of beholding the long beautiful evening of their life glorified by a sun-like splendour of success and worldly fame, poor Lamarck closed his long and laborious life misunderstood, solitary and needy. Ten years before his death he suffered the misfortune of blindness, and could only from memory dictate the last part of his great natural history of invertebrate animals to his two daughters who tenderly nursed him, and whom he left behind him without any means of support. Let us hope that the bitterness of his hard fate was qualified by the consciousness of his having cast the deepest glances into the mysteries of creative nature, and that the clear intellectual eye of the blind prophet often descried the laurel garland which thankful posterity would one day lay on his lonely grave.

Unquestionably the greatest defect in Lamarck's work was the insufficiency of the stock of observations and experiments he brought forward in proof of his far-reaching principles. For then, as now, the great majority of naturalists want, above everything, to have palpable facts in the hand. Then as now we find the paradoxical phenomenon, that the great majority of people accept without any misgiving and trample under foot the most absurd hypotheses and dogmas, while on the other hand they encounter well-founded scientific theories with the more suspicion and opposition the more they approach the truth. Among the experimental proofs of theories, moreover, to most people those are not the most welcome which are furnished by a continuous series of phenomena and a whole large class of facts. What they most desire is the particular observation, the single experiment. A large part of Darwin's immense success is due to the fact that he brought into the field to a truly overwhelming amount exactly such particular pertinent observations and experiments. Poor Lamarck on the contrary, trusting to the logical conclusion-drawing faculty of naturalists, for the most part neglected the business of palpable particulars.

The comparison of these three great natural philosophers in whom the foundation-laying development theory of our current natural science was most powerfully and comprehensively revealed is of high interest, for all three are very different among themselves both in respect of their general genius and the fortunes of their life outwardly and inwardly, as also, very especially, in respect of their courses of study and the ways by which they pursued their high aims. Lamarck starts from the most careful special studies of individual animal and vegetable forms, and by his many years' systematic examination and comparison of them is brought to the conviction that all living and fossil species have developed themselves out of a few simple common geneological forms. Goethe arrives at the same conclusion on the ground of his general studies in comparative morphology, directed by the conviction that the unity of the common type or the hereditary protoform can be traced out, everywhere in all the different organic forms, however manifoldly they may be transformed in individuals through adaptation to outward circumstances. Darwin, finally, first answers to his own satisfaction the question by what causes the new culture-forms of animals and plants reared by men come into being, and then demonstrates that the struggle for existence is the same cause which in like manner by the inter-action of adaptation and inheritance constantly produces new organic species in the free state of nature.

In these wholly different ways and by application of wholly different methods of investigation, all these three naturalists arrive ultimately at the same conclusion—to the acceptance, namely, of a monistic and continuous development of the whole of organic nature, through the operation alone of natural causes, to the exclusion of all supernatural creative miracles. All three, however, being at the same time deep-thinking philosophers and keeping constantly in their eye the unity of the whole world of phenomena, their idea of development expands to a grand pantheistic conception of the world, to that doctrine of oneness which forms the essence of our current monistic theory of nature.

The immeasurable effect which the decided triumph of this monistic view of nature already in this day exercises on all provinces of human knowledge, an effect increasing in geometrical progression from year to year, opens to us the happiest prospect regarding the further intellectual and moral development of mankind. I repeat here my firm personal conviction that in future this progress of scientific knowledge will be esteemed the greatest turning-point in the intellectual history of man.

We would in a quite especial manner emphasise this reconciling and compensating influence of our genetic theory of nature, all the more that our opponents are constantly endeavouring to obtrude disruptive and decomposing tendencies on it. These destructive tendencies are said to be directed not merely against science, but against religion and so against the most important foundations, in general, of our civilised life. Such grievous charges, so far as they really rest on conviction and not merely on sophistic fallacies, can be explained only by the fact of a mischievous misunderstanding of what forms the genuine kernel of true religion. This kernel does not consist in the special form of one's confession of faith, but rather in the critical conviction of an unknowable, common, ultimate ground of all things and in practical ethics springing immediately from the purified theory of nature.

In this confession, that with the present organisation of our brain the last ultimate ground of all phenomena is unknowable, the critical philosophy of nature comes athwart dogmatic religion. This faith in God, however, of course, assumes, endlessly different forms of confession according to the endlessly different degrees of the knowledge of nature. The further advances we make in the latter—the more we approach that unattainable ultimate ground—the purer will be our idea of God.

The purified knowledge of the world in the present day knows that natural revelation alone which in the book of nature lies open to every one and which every unprejudiced man with sound senses and sound reason can learn out of it. From this is derived that purest monistic form of faith which attains its climax in the conviction of the *unity of God and Nature* and which has long ago found its most complete expression in the confessions of our greatest poets and thinkers, Goethe and Lessing at their head. That Charles Darwin, too, was penetrated by this religion of nature, and did not acknowledge a particular church-confession is patent to every man who knows his works. . . .

Only in law-regulated society can man acquire the true and full culture of the higher human life. That, however, is only possible when the natural instinct of self-preservation, Egoism, is restricted and corrected by consideration for society, by Altruism. The higher man raises himself on the ladder of culture, the greater are the sacrifices which he must make to society, for the interests of the latter shape themselves evermore to the advantage of the individual at the same time; just as, reversely, the regulated community thrives the better the more the wants of its members are satisfied. It is therefore quite a simple necessity which elevates a sound equilibrium between Egoism and Altruism into the first requirement of natural ethics.

The greatest enemies of mankind have ever been, down to the present day, ignorance and superstition; their greatest benefactors, on the other hand, the lofty intellectual heroes who with the sword of their free spirit have valiantly contended with those enemies. Among these venerable intellectual warriors stand at the head, Darwin, Goethe, and Lamarck, in a line with Newton, Keppler, and Copernicus. These great thinkers of nature by devoting their rich intellectual gifts, in the teeth of all opposition, to the discovery of the most sublime natural truths, have become true saviours of needy mankind, and possess a far higher degree of Christian love than the Scribes and Pharisees who are always bearing this phrase in their mouth and the opposite in their heart.

How little, on the other hand, blind belief in miracles and the domination of orthodoxy is in a position to manifest true philanthropy is sufficiently testified not only by the whole history of the middle ages but also by the intolerant and fanatic procedure of the militant church in our days. Or must we not look with deep shame on those orthodox Christians who, in our day, again express their Christian love by the persecution of those of other faith and by blind hatred of race? And here in Eisenach, the sacred place where Martin Luther delivered us from the gloomy ban of adherence to the letter, did not a troop of so-called Lutherans venture some years ago to try anew to bend science under that yoke?

Against this presumption on the part of a tyrannical and selfish priesthood it will to-day be permitted us to protest on the same spot where 360 years ago the great Reformer of the church kindled the light of free inquiry. As true *Protestants* we shall rise up against every attempt to force independent reason again under the yoke of superstition, no matter whether the attempt be made by a church sect or a pathologic spiritism.

Happily we are entitled to regard these mediæval relapses as but transitory aberrations which will have no abiding effect. The immeasurable practical importance of the natural sciences for our modern culture-life is now so generally recognised that no section of it can any longer dispense with it. No power in the world is able again to roll backwards the immense progress to which we owe our railways and steamers, telegraphy and photography, and the thousand indispensable discoveries of physics and chemistry.

Just as little, too, will any power in the world succeed in destroying the theoretic achievements which are inseparably bound up with those practical successes of modern science. Among those theories we must assign the first place to the development doctrine of Lamarck, Goethe, and Darwin. For by it alone are we authorised firmly to establish that comprehensive *oneness of our theory of Nature* in which every phenomenon appears as but efflux of one and the same all-comprehensive law of nature. The great law of the conservation of force thereby finds its universal application, embracing also those biological provinces which hitherto appeared closed to it.

In face of the surprising velocity with which in these last years the development theory has paved an entrance into the most diverse departments of inquiry we may here express the hope that its high pedagogic value also will be even more recognised, and that it will quite perfect the education of the coming generations. When five years ago, at the fiftieth Meeting of Naturalists in Munich, I laid stress on the high significance of the development theory in relation to education, my remarks were so misunderstood that a few words of explanation may here be allowed me. It stands to reason that with these words I could not mean to claim that Darwinism should be taught in elementary schools. That is simply impossible. For just like the higher mathematics and physics, or the history of philosophy, Darwinism demands a mass of previous knowledge which can be acquired only in the higher stages of learning. Assuredly, however, we may demand that all subjects of education be treated according to the *genetic method*, and that the fundamental idea of the development-theory, the *Causality of Phenomena*, find everywhere its acknowledgment. We are firmly persuaded that by this means, thinking and judging conformably with nature will be promoted in far greater measure than by any other method.

At the same time through this extended application of the development-doctrine, one of the greatest evils of our day in the culture of youth will be removed—the cramming of the memory, we mean, with dead lumber, which smothers the best powers and prevents both soul and body from coming to a normal development. This excessive cramming is based on the old fundamental ineradicable error that the *quantity* of *factual knowledge* is the best measure of culture, while, in truth, culture depends on the *quality* of causative *science*. We would therefore deem it especially useful that the selection of the material of instruction be much more carefully made, and that in making the selection, those departments which cram the memory with masses of dead facts do not receive the preference, but those which cultivate the judgment through the living stream of the development idea. Let our worried school youth only learn half as much, but let them understand this half more thoroughly, and the next generation will in soul and body be doubly as sound as the present.

In the most gladdening manner these requirements are being met by the reforms which are simultaneously in process of accomplishment in the most diverse provinces of science. Everywhere is stirring and moving fresh young life, stimulated by the idea of natural development—in the Comparative Study of Languages and in the History of Culture, as also in Psychology and Philosophy; in Ethnography and Anthropology no less than in botany and zoology. Everywhere the most joyful blossoms are bursting forth from the most varied branches of science, and its fruits will concurrently testify that they all spring from one single tree of knowledge and draw their nourishment from one single root. Thanks and honour, however, to the great masters who by their genetic and monistic theory of nature have led us to this clear height of knowledge from which with Goethe we may say:

> "Dieser schöne Begriff von Macht und Schranken, von Willkür
> Und Gesetz, von Freiheit und Mass, von beweglicher Ordnung
> Vorzug und Mangel, erfreue dich hoch; die heilige Muse
> Bringt harmonisch ihn dir, mit sanftem Zwange belehrend.
> Keinen höhern Begriff erringt der sittliche Denker,
> Keinen der thätige Mann, der dichtende Künstler; der Herrscher,
> Der verdient es zu sein, erfreut nur durch ihn sich der Krone.
> Freue dich höchstes Geschöpf der Natur, du fühlest dich fähig,
> Ihr den höchsten Gedanken, zu dem sie schaffend sich aufschwang
> Nachzudenken. Hier stehe nun still und wende die Blicke
> Ruckwärts, prüfe, vergleiche und nimm vom Munde der Muse,
> Dass du schauest, nicht schwärmst, die liebliche volle Gewissheit."[1]

OUR ASTRONOMICAL COLUMN

THE BINARY STAR 70 OPHIUCHI.—This star has received even more than a fair share of attention at the hands both of observers and computers, but there remain notwithstanding large outstanding differences between observation and calculation. As regards the orbit a very complete discussion of all the reliable measures to 1868, was made by Dr. Schur of Strasburg, while with eight years later measures, the elements were rigorously investigated by M. Tisserand in a memoir published by the Academy of Sciences of Toulouse. If Dr. Doberck in the course of his skilful and elaborate researches on the motion of the binaries has given attention to this star, his results have escaped our notice, but we subjoin the orbits deduced by Dr. Schur and M. Tisserand:—

	SCHUR.	TISSERAND.
Periastron passage ...	1808·791	1809·664
Node	125° 22′	127° 22′
Node to periastron ...	155° 44′	149° 44′
Inclination	57° 56′	60° 0′
Excentricity	0·49149	0·47287
Semi-axis major	4″·704	4″·770
Period of revolution ...	94·370 years ...	... 94·929 years.

In 1879 the star was measured by Prof. Asaph Hall on five nights with the 26-inch refractor at Washington, generally under a magnifying power of 600; his epoch is—

$$1879{\cdot}588 \quad \ldots \quad \text{Position, } 71^{\circ}{\cdot}32 \quad \ldots \quad \text{Distance, } 2''{\cdot}930$$

Comparing with Schur's elements we find—

$$dP\,(c - o) = +\,5^{\circ}{\cdot}61 \quad \ldots \quad \ldots \quad dD = +\,0''{\cdot}726$$

While the errors of Tisserand's orbit are—

$$dP = +\,3^{\circ}{\cdot}01 \quad \ldots \quad \ldots \quad \ldots \quad dD = +\,0''{\cdot}497$$

The question naturally arises, how is it that after the most careful and complete determination of the orbit, it happens that in so short a time after the date of the latest measures employed in the calculations, the star appears to *bolt*, so to say, from its predicted course.

There have been suspicions from time to time that perturbation is indicated by the apparently anomalous differences between observation and computation. Mädler, discussing the elements of the orbit in 1842, when truly he had but a very limited and comparatively imperfect series of measures at his command to what we can now utilise, went so far as to doubt the efficiency of the theory of gravitation to explain the motion of the components of this double star, or at least he considered the question reduced to one of two alternatives, which he thus presents:—

(1) "The motion in this binary system does not follow the Newtonian law."

Or (2) "The middle point of the images which the stars form to us is not the centre of gravity of the masses."

And he recommended the star to close scrutiny with the most powerful instruments, with the view to ascertain whether there were any visible disturbing body.

The existence of a third star was suggested by Jacob, to explain similar anomalies which he believed to have been indicated by the measures, but Mr. Burnham, in 1878, examined 70 Ophiuchi with the 18½-inch Alvan Clarke refractor at Chicago with only negative evidence: "Both stars were perfectly round, with the highest powers on this occasion, . . . and no trace of any third star near." Such had also been his previous experience.

It thus becomes all the the more desirable to ascertain how far the suspected deviations from unperturbed motion may exist in the observations themselves, and more attention might perhaps be given with advantage to the investigation of personal equation between the various observers, the elimination of the effect of obliquity of direction of the components, or other cause which could possibly affect the comparison of the separate results. The evidence that such influences exist is pretty evident in the case of this particular star. For instance if we compare the above orbits with an epoch, only one year later than that of Prof. Hall, viz., Jedrzejewicz's for 1880·656, giving the position 62°·82, distance 2″·75, we get the following differences between calculation and observation:—

In Schur's orbit ... ... $dP = +10^{\circ}{\cdot}81$ ... $dD = +0''{\cdot}72$
In Tisserand's orbit ... $dP = +\ 7^{\circ}{\cdot}88$ ... $dD = +0''{\cdot}51$

Exhibiting an increase of errors in the course of a year which cannot be wholly attributed to errors of elements depending upon a long course of measures.

Another circumstance connected with 70 Ophiuchi, which is attended with some difficulty of explanation, may be mentioned here. Prof. Hall, in addition to measuring the principal com-

---

[1] This fair idea of might and limit, of will and law, of freedom and measure, of order in movement, of excellence and defect, gladden thee deeply; the holy Muse brings it harmoniously to thee, instructing thee with generous constraint. No higher idea achieves the moral thinker, no higher the active man, the creative artist; the regent worthy to rule finds happiness in his crown through this idea alone. Rejoice, oh highest creature of Nature, that thou feelest thyself able to think after Nature the highest thought to which the creatively soared. Here now stand still, and turn thy looks backwards, examine, compare, and hear the words of the Muse, that without illusion thou mayest contemplate the full, lovely truth